A TERTIARY CRINOID FROM THE WEST INDIES.

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In the year 1922 there were submitted to me by Dr. Wendell P. Woodring, of the Haitian Geological Survey, some fragmentary crinoidal remains discovered during a cooperative reconnaissance of the Republic of Haiti, which upon examination proved to belong to the pentacrinid genus *Balanocrinus* Agassiz in Desor. The fossils were derived from strata of early Miocene age in the interior of the island.

The occurrence is of interest as being the second one of this genus recorded from North America, the first having been described by me in 1922 from Tamaulipas, Mexico, as *Balanocrinus mexicanus*, based upon material discovered by Dr. L. W. Stephenson, of the Geological survey.[1] That species, however, is from Upper Cretaceous rocks, so that by the present occurrence the geological range of this European genus in the Western Hemisphere is greatly extended. The known range of *Balanocrinus* in Europe is from Triassic to Miocene, most of the species having been described under the name *Pentacrinus*. The latest occurrence there is in the upper Helvetian of the middle Miocene in Piedmont, Italy, evidenced by stems described by Noelli in 1900 as *Pentacrinus lorioli*,[2] and referred by Bather to *Balanocrinus* in the Zoological Record for 1900 (p. 143).

The beds in which the crinoid remains under consideration were found belong to the Artibonite formation of the lower Miocene, equivalent to the lower part of the Yaque group of the Dominican Republic. This has been correlated by Cooke and Vaughan with the Burdigalian of the European time divisions.[3] A full account by Messrs. Woodring, Brown, and Burbank of the Tertiary stratigraphy of Haiti, containing a notation of the present discovery, will appear in a forthcoming report.[4]

[1] Proc. U. S. Nat. Mus., vol. 61, art. 5, pp. 1–4.

[2] Contribuzione allo studio dei Crinoidi Tertiari del Piemonte, Atti. Soc. Ital. Sci. Nat., vol. 39, 1900, p. 28, pl. 1, figs. 33, 34. See also Bather, Ann. and Mag. Nat. Hist., ser. 8, vol. 20, Dec. 1917, p. 405.

[3] Geological Reconnaissance of the Dominican Republic Memoirs, vol. 1, 1921, pp. 57, 65, and 96.

[4] Geology of the Republic of Haiti: Republic of Haiti Geol. Survey (awaiting publication).

The history and characters of the genus *Balanocrinus* have been exhaustively discussed by Dr. F. A. Bather, of the British Museum, in connection with a rediscription of the two leading species from the middle and upper Eocene of the London clay and the Nummulitic beds of Biarritz, France;[5] and reference should be had to this important paper for the fullest information upon the subject.

The Haitian material consists of 24 stem-fragments, ranging from a maximum length of 41 mm. down to short pieces of only two or three columnals. The longer pieces from 25 to 41 mm. in length have 9, 10, 11, 12, 14, and 16 columnals, the number 14 being the most frequent. It seems probable that some of these represent complete internodes, or intersyzygia, although in none of them are two terminal syzygial faces perfectly shown. The preservation of the specimens is mostly rather poor, the surfaces being more or less covered with carbonate of iron and the edges at the joints often considerably frayed; but enough remain intact in several instances to disclose the joint faces characteristic of the genus.

Comparison is naturally suggested with the Italian species of nearly equivalent horizon, but in order to establish the record it will be best first to describe the Haitian form as a new species.

BALANOCRINUS HAITIENSIS, new species.

Plate 1, figs. 1–10*a*.

Known only from stem-fragments. One of the two longest is 41 mm. in length, tapering from 7 to 6 mm. in diameter, composed of 16 columnals averaging about 2.5 mm. in height (fig. 1); this probably embraces a complete internode, of which the terminal ossicles at either end were cirrus bearing, the evidence of which is obscure, but is reinforced by comparison with the syzygial face in some other specimens. Another of nearly the same length (fig. 8) contains 12 columnals 8.5 to 9 mm. in diameter, averaging 3 mm. high, plus a lower one at each end; one of these is clearly the epizygal, having two cirrus-facets at adjacent radii pointing obliquely upward (drawn with this end uppermost for better lighting), and faint indication of a third one opposite to these two; the corresponding columnal at the other end shows indistinct traces of three cirrus facets alternately placed. Two other pieces (not figured), 39 and 35 mm. in height, have 16 and 14 columnals, respectively, of which the terminal faces may be syzygial, thus giving 14 and 12 ossicles to the internode; these terminal ossicles seem rather shorter than the others, but cirrus-facets are not seen. A fifth piece of 33 mm. in length has 14

[5] British Fossil Crinoids, XI, *Balanocrinus* of the London Clay. Ann. and Mag. Nat. Hist., ser. 8, vol. 20, Dec. 1917, pp. 385–407.

columnals, of which the upper one, with the radial structures much injured by corrosion, may be a nodal, but no facets are visible (figs. 4, 4*a*). In this specimen it is seen how the radial ridges have been partly decomposed, leaving the petal floors between them prominently preserved. This condition is further shown in Figure 6*a*, where the ridges are destroyed and the resulting pentamerism is emphasized. In Figures 4, 5, and 6 the effect of weathering and decomposition upon the sides of the stem is shown, producing more or less longitudinal projections, in some rounded and in some angular. Figures 2 and 3 show the distortion of the columnals by crushing.

All the stem-fragments in their normal condition, that is, when unaffected by weathering, crushing, or chemical action, are strictly cylindrical in outline. The slightly quinquelobate aspect on some of the joint faces is due to peripheral abrasion along the weaker radial lines at the edge of the sectors. The stems range from 6 to 9 mm. in diameter, with about 8 mm. preponderating. The side faces are invariably smooth except where injured, as shown in several figures.

Returning, now, to the cirrus-facets, we are fortunate in having one specimen in which they are very plainly shown upon the syzygial face of one of the nodal segments, which I suppose to be the epizygal (figs. 9, 9*a*). They are three in number, two at adjacent radii and the third directly opposite these two, leaving the space at the intervening radii blank. They stand obliquely to the syzygial face, projecting somewhat from its general level, and their position is marked by obtuse ridges diminishing inward and engaging with corresponding depressions in the apposed face of the contiguous nodal segment. In another specimen, not figured, similar facets of the same number and position are faintly indicated. The two facets shown in Figure 8, with a third one opposite to them obscurely seen but not visible in the figure, are similarly disposed. Therefore upon the concurrent evidence of three specimens it may be fairly assumed that the normal number of cirri in this species is three to a nodal, distributed according to the definite plan described by Doctor Bather in his paper of 1917 (p. 396) as "not (all) adjacent, but one is opposed to the two others, being separated from them on each side by a blank radius . . . symbolized thus:

A b C D e."

He shows how the cirrus-facets alternate upon successive nodals, and the same thing probably happens here, there being, as already stated, some evidence of such an alternation in the facets on the terminal nodals in Figure 8. The cirrus-facets are extremely small compared with the size of the stem, not over half the height of the nodal pair, thus resembling those of the Eocene species, *B. sub-*

basaltiformis as figured by E. Forbes.[6] They are in marked contrast to those of the enormous cirri of *B. mexicanus*,[7] in which the cirrus-facets fill almost the entire height of the combined nodals. In none of the specimens is any portion of the cirrus itself preserved.

The normal joint-face in nearly all the specimens is so much decomposed that the details of structure are usually obliterated, but as before there is fortunately one specimen in which these are well preserved, showing distinctly the unmistakable characters of *Balanocrinus* (figs. 10, 10*a*). The petaloid sectors are thoroughly well marked; the floors, or ligament fossae, are large, obtusely triangular, considerably depressed, or excavate. In each sector there are about 10 peripheral crenellae at right angles to the periphery, with usually another one at either side next to the radius not reaching the periphery, which according to Bather's terminology would be called adradials, thus making 12 crenellae in all; they are short, those which are strictly peripheral being about one-forth the length of the radius, here again contrasting with those of *B. mexicanus*, in which the length of the crenellae is from one-third to two-thirds that of the radius. On the syzygial face the crenellae are shorter, but apparently somewhat less in number (fig. 9*a*). In other specimens the narrow radial ridges are conspicuous, straight, apparently separated by the radial canal, but perhaps partly confluent (figs. 4*a*, 5*a*). The axial canal is apparently round, and the lumen very small.

The species with which comparison is invited is the one from the later middle Miocene horizon of Italy, already mentioned, *Balanocrinus lorioli* of Noelli. It is described from three stem fragments, of which two are figured, respectively 17 and 8 mm. in length, about 6 mm. in diameter, with 9 and 4 columnals about 2.5 mm. in height. The columns are said to be subpentagonal, and have exteriorly some longitudinal furrows, with one or more rows of small pores alternating with them, some of which may be exposed by weathering. Two normal joint faces are figured, both obscure in details of structure. According to the text each petal has 7 to 10 crenulae (denti) at the periphery. The differences shown by comparison of stem fragments alone are therefore of rather minor importance, not greater than might be found in different parts of the same stem. However, we have to make the best of such evidence as we have, considering the rarity and imperfection of the specimens.

That which does give to our species a very special interest is the fact that its occurrence in the Miocene of the West Indies furnishes

[6] Monog. Tertiary Echinod, Palaeontogr. Soc., 1852, pl. 4, figs. 8, 9, 10.
[7] Proc. U. S. Nat. Mus., vol. 61, 1922, pl. 1.

a notable addition to the extremely small number of Tertiary crinoids that are known. When we consider the vast extent of Eocene and Miocene sedimentaries of marine origin in Europe, Asia, Africa, Australia, the United States, West Indies, Central and South America, many of them thousands of feet in thickness and richly fossiliferous, abounding in crustaceans, corals, mollusks, and other organisms everywhere associated with crinoids, in ages preceding the Tertiary as well as in the present seas, it is remarkable how few are the remains of crinoids which they have yielded. About 40 species, embraced in 8 or 9 genera, will cover all that have been described, most of them from very imperfect material, such as isolated columnals of pentacrinites and centrodorsals of comatulids, among which are doubtless a number of synonyms. Well-preserved specimens, such as are so frequent in the Jurassic and Cretaceous, are almost unknown in the Tertiary, about all we know of the crinoid life of that age being derived from the fragmentary remains above mentioned, and even these are of rare occurrence.

Of the restricted number of species hitherto known, only a single one has been derived from American rocks, namely, the cup of a small comatulid belonging to the Thalassometrinae from the Eocene of North Carolina, described by Emmons[8] as *Microcrinus conoideus*. A few other fragmentary remains, not hitherto noted or described, occur in the same beds, and specimens of a species of a comatulid, *Nemaster*, have been found in the Eocene of South Carolina—all fragmentary and extremely rare amid a profusion of other fossils.

Therefore the present species coming from the West Indies is the first stalked crinoid of Tertiary age to be described from the Western Hemisphere. To it will be added another occurrence probably of the same genus, from the island of Tierra del Fuego, which Doctor Bather informs me he will shortly describe.

Recent investigations in the West Indies and Panama[9] have shown an extraordinary development of marine Tertiary formations, especially in the Haitian and Dominican Republics, which in places aggregate as much as 1,200 to 2,400 meters in thickness, in many places filled with fossils. Yet out of the extensive collections made during these researches and those previously made by other geologists the 24 fragments upon which this species is based, from a single limited locality, represent all the fossil crinoid remains that have been reported from the West Indies and adjacent lands, a region in the waters of which they are now quite plentiful, amounting as thus

[8] North Carolina Geological Survey, 1858, p. 311, figs. 246, 247.

[9] Vaughan, T. W., Contributions to the Geology and Paleontology of the Canal Zone, Panama, and geologically related areas in Central America and the West Indies, 1919. Bulletin 103, U. S. National Museum.

far described to 51 species, distributed among 31 genera, of which 12 species, belonging to 8 genera, are of the stalked type.[10]

The crinoids existed in the Mesozoic in great profusion, their fossil remains having been found to the number of upward of 400 described species, belonging to more than 40 genera, many of them perfectly preserved and some of cosmopolitan distribution; while in contrast to the scant 40 species known from the Tertiary there are now described from existing seas 576 species of crinoids, belonging to 142 genera, of which 76 species, of 22 genera, are of the stalked variety. The question naturally arises, what became of the crinoids in the meantime?

The scarcity of crinoids in the Tertiary, and the fragmentary condition of their remains, is indeed surprising when compared with their relative abundance in the Jurassic and Cretaceous and also in the recent seas. And yet if the present reefs and beaches were known only in a fossil condition we should find exactly the same state of affairs.

The marine Tertiary sedimentaries are composed chiefly of littoral and reef materials, laid down in shallow seas. The fossils which abound in them belong mostly to organisms of which the hard parts are firmly constructed and capable of enduring the effect of shore action. The crinoids of Cenozoic time, on the other hand, are delicately organized and of fragile construction, so that with a few exceptions like *Holopus* they are broken up with the least disturbance.

When a comatulid dies—and comatulids are extremely sensitive—it at once disintegrates, and the only recognizable portion that remains is the radial pentagon with the controdorsal, or either of the two alone.

The reefs of to-day support a crinoid fauna of approximately 245 species, all of the comatulid type. Most of these are very local, occurring only in a few limited regions, and many are very rare. In the Caribbean region, where in the deeper waters crinoids are often abundant, the shore line records are:

Nemaster grandis A. H. Clark: "Mexico," 1758. *Nemaster iowensis* (Springer): Tortugas, 1893; Bahamas. *Antedon dübenii* Böhlsche: St. Thomas, about 1850. *Cenocrinus asteria* (Linnaeus): Barbados, about 1870. *Holopus rangii* D'Orbigny: Barbados, 6 records; ? Bermuda. *Democrinus rawsonii* (Pourtales): Guadeloupe.

A recent reef if fossilized might show, as extremely rare objects confined to a very few closely circumscribed localities, the radial

[10] See Austin H. Clark, 1921. Report on the Crinoids collected by the Barbados-Antigua Expedition from the University of Iowa, in 1918. University of Iowa studies in Natural History, vol. 9, No. 5, pp. 12–14.

pentagons and centrodorsals of comatulids. Such remains have actually been found at Newcastle, New South Wales, Singapore, Taranto, and on the coast of Kent in England.

Not far below the surface in a few widely separated localities live large pentacrinites, *Holopus*, and *Democrinus*.

The crowns of the pentacrinites are almost as fragile as the comatulids, and very soon go to pieces, while the arms of *Democrinus* are extremely fragile, and the column is rather brittle.

Since Dr. W. B. Carpenter reported that once after a hurricane the beach at Barbados was strewn with pentacrinites of all sizes, and 7 of the 11 known specimens of *Holopus rangii* were found on the beach (6 of them at Barbados), and the first known species of *Democrinus* was described from a recent breccia at Guadeloupe containing a human skeleton, it follows that a recent reef if fossil might contain fragments of pentacrinite stems, fragments of *Democrinus* stems, or well-preserved specimens of *Holopus*.

As the foregoing sketch gives a fairly complete survey of what we might expect if the present reefs and beaches were known only as fossil strata, we may hazard the assumption that the scarcity of crinoids in the Tertiary means nothing more nor less than that at that time the crinoids first began to exist chiefly under the conditions delimiting their occurrence at the present time.

Horizon and locality.—Artibonite formation, lower Miocene, Tertiary. Divide on trail between La Chapelle and Mirebalais. Republic of Haiti. Collected by J. S. Brown, December 18, 1920. U. S. Geological Survey loc. No. 9494.

Type.—In U. S. National Museum, Cat. No. 352556.

EXPLANATION OF PLATE.

All figures are enlarged about two diameters.

Balanocrinus haitiensis new species.

Lower Miocene. Island of Haiti.

FIG. 1. The longest stem-fragment, about 41 mm., with a longitudinal row of irregular pits along the radial line due to erosion or chemical action.

FIGS. 2, 3. Specimens showing distortion of the stem produced by crushing, the first having probably a cirrus-facet preserved.

FIGS. 4, 4*a*. Two views of a stem-fragment with the convex edge of some petals exposed by erosion at the side and top, and at the latter the remnant of what is probably the normal joint-face with the radial ridges much eroded, leaving petal floors rounded and prominent; only faint traces of crenulae remain.

FIGS. 5, 5*a*. Side and terminal views of a stem-fragment with sides eroded along longitudinal radial lines, leaving the interradial sectors convex; the upper face being possibly a syzygial joint, with obscure traces of cirrus-facets, the radial ridges rounded and their bordering furrows distinctly outlined; some peculiar striae are seen in two of the petal areas.

FIGS. 6, 6*a*. Side and terminal views of a stem-fragment altered somewhat like the last, but in which the radial structures have been destroyed by chemical action, leaving the more substantial petal sectors strongly outlined, but without trace of crenellae.

FIG. 7. A stem with smooth, unaltered sides, except near the upper end, where there is the remnant of a cirrus-facet.

FIG. 8. A smooth stem with probably a nodal columnal at each end. Two cirrus-facets are clearly shown at the upper face, at adjoining radii.

FIGS. 9, 9*a*. Two views of an unaltered stem-fragment, with the epizygal at the top (so posed in photographing for better lighting of the structures), showing 3 cirrus-facets well preserved, oblique to the general surface, two at adjoining radii, and the third one opposite, leaving the two intervening radii blank. The peripheral crenellae are distinct in some parts of this face, but no trace of radii can be seen upon it.

FIGS. 10, 10*a*. Two views of a fragment consisting of two columnals, on one of which the normal joint-face is in good condition. The petal floors are depressed, as usual in the genus, the radial ridges slightly elevated between them, indented with faint narrow canals leading to the radial center; the peripheral crenellae are distinct, 10 or 12 in number to the sector, with the outer pair next to the radii slightly receding from the margin.